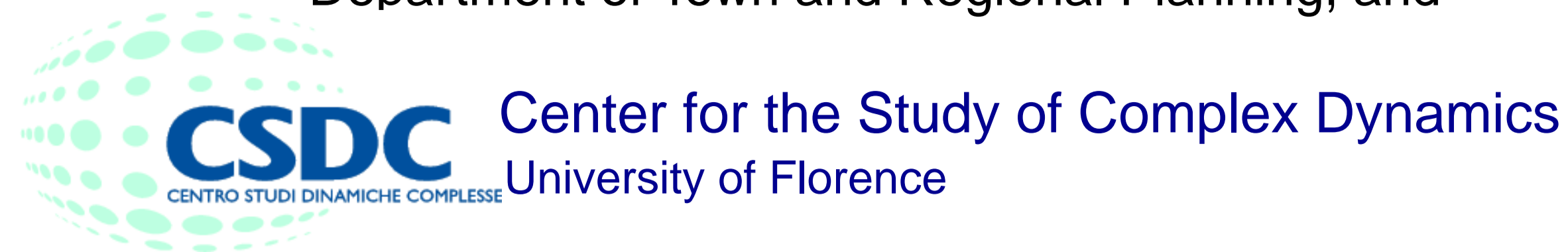


The comprehensive agent-based simulation of the urban dynamics.

The CityDev model

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1 Introduction

The complex urban system results from the interaction of a lot of individuals. Therefore an agent-based system is the best suited for simulating this complex interaction. This is the case of CityDev, an urban multi-agent model which includes the whole aspects of the urban system and allows human users to interact.

CityDev is based on agents, goods and markets. Each agent produces goods by using other goods and trades the produced goods in the markets. To perform their tasks agents need a building. Thereby, the evolution of the urban fabric results from the agents' interaction. A grid of 100×100 squared land cells, is the spatial pattern of the simulation. The buildings of the city are considered as composed of indivisible 3-D cells which can be superposed in case of a multi-floors building, thus generating a mix of land uses and a varying of the density.

2 Agent, goods, and markets

Agents are distinguished in two main sub-classes in relation to its main goal: consumers and producers. Households belong to the first group, while industrial firms, commercial firms, private service firms, public services, and developers belong to the second group. Consumers maximize the quantity of consumed goods, under the constraint of an established budget, while producers maximize the earnings under the constraint of a production function.

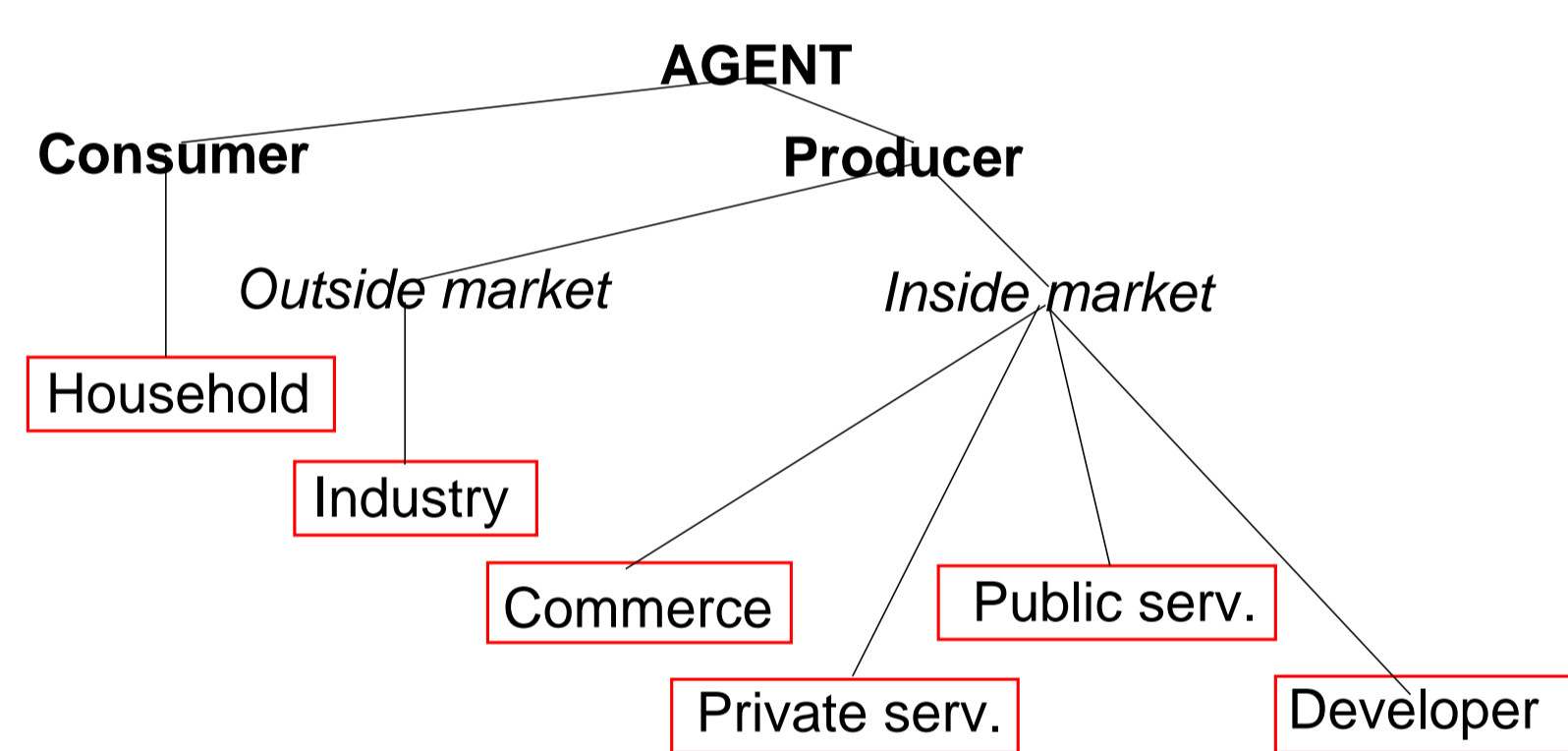


Figure 1: The hierarchy in the agents classes. Each framed sub-class at the bottom of the hierarchy can be instantiated thus generating the individual agents.

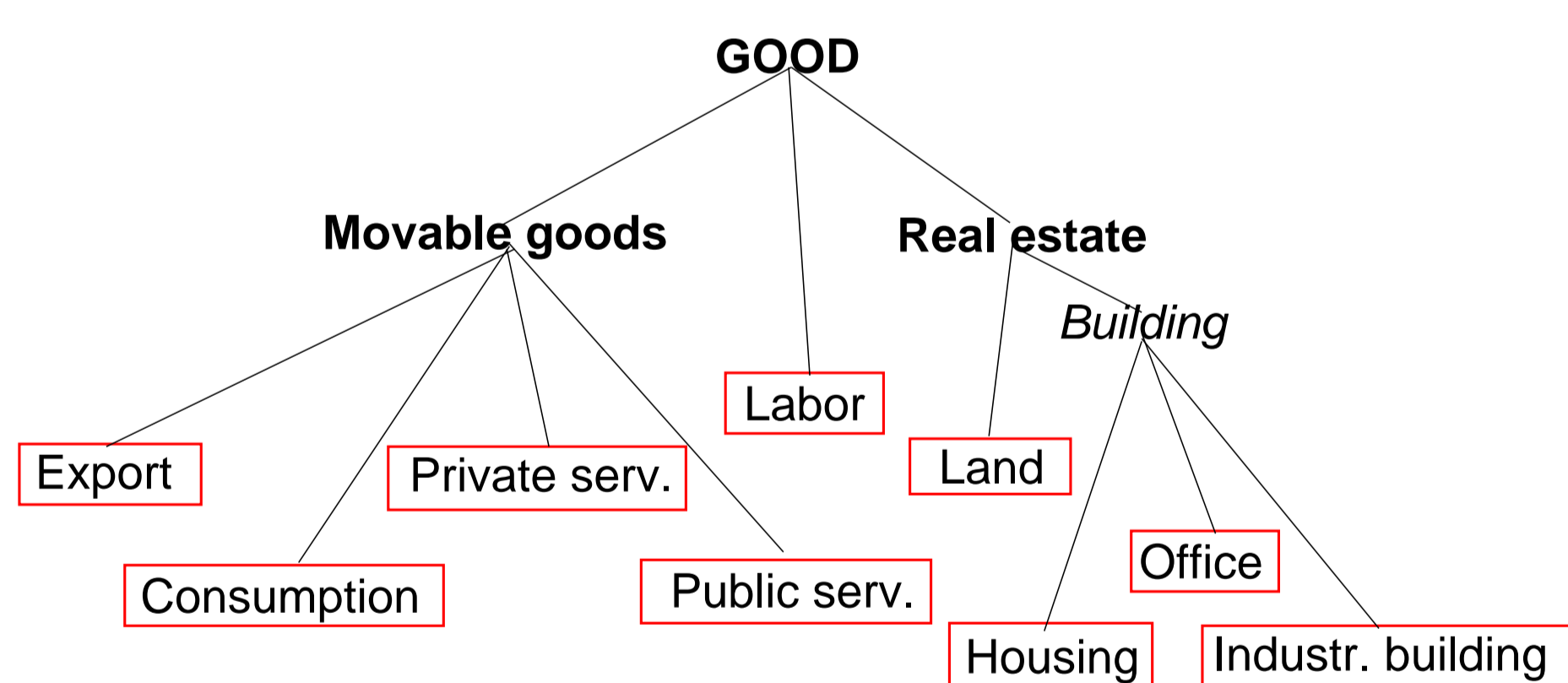


Figure 2: The hierarchy of the main goods classes. Each framed sub-class at the bottom of hierarchy, can be instantiated thus generating an individual good

To exchange goods and services, markets are provided. A specialized market exists for each good or service. In each market agents offer the goods they have produced, set a price for each good and sell it to the first buyer agreeing with this price, or to the highest bidder.

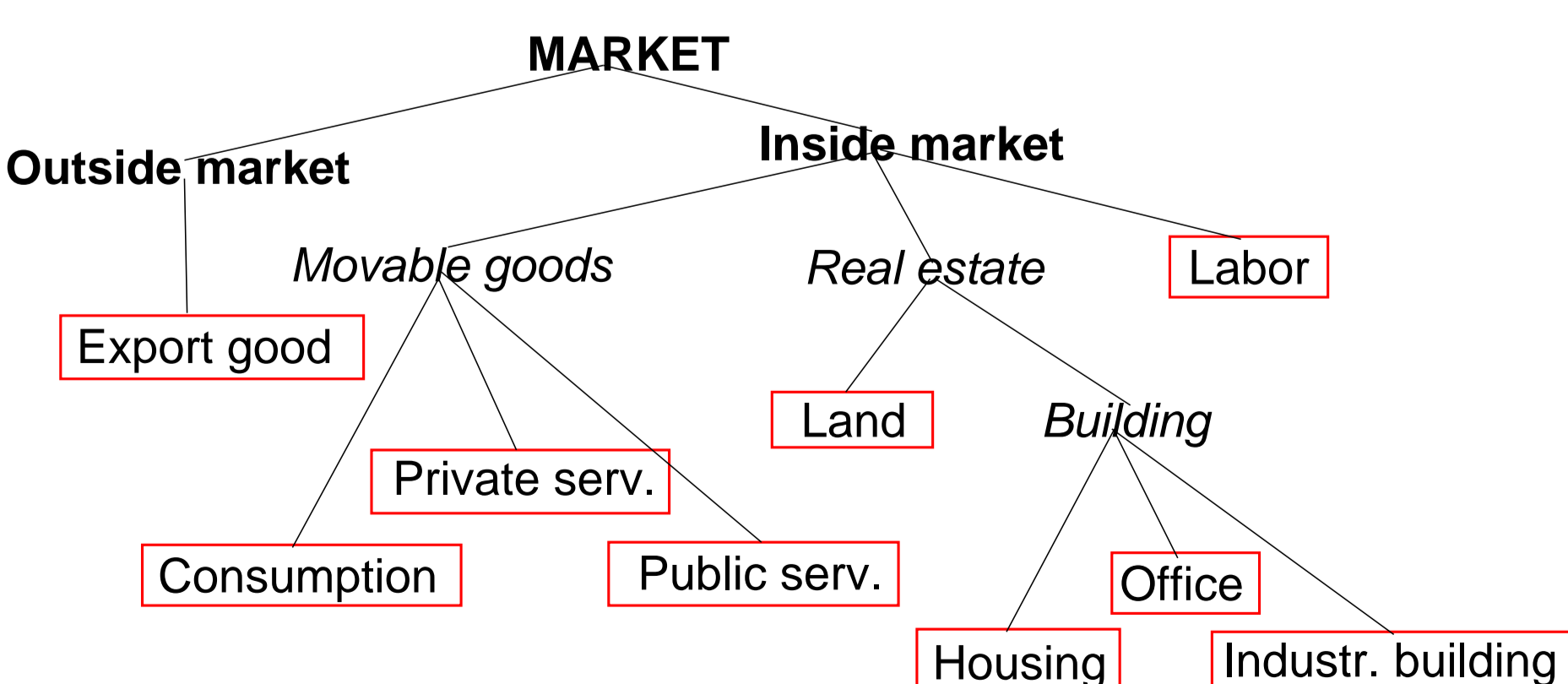


Figure 3: The hierarchy of the main markets classes. Markets cannot be instantiated: they are singleton classes.

3 The dynamic system

The macro-economics dynamics of model is rooted in the economic base theory: an outside demand of industrial product stimulates the production of exogenously related sectors, such as industry. Households are generated which work in industrial firms. Because households demand final consumption goods, commercial firms are generated, which in turn employs workers and so on.

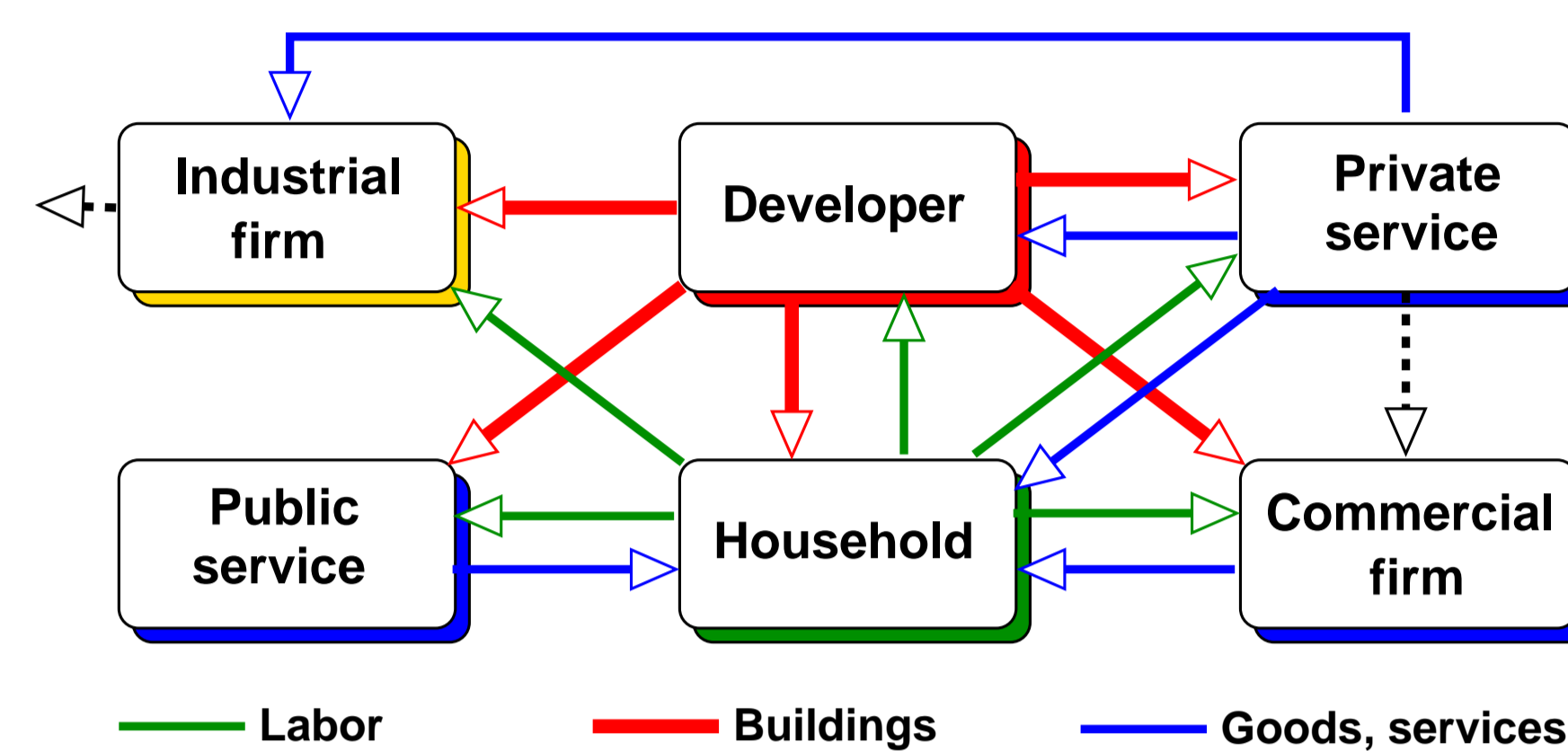


Figure 4: The network of interactions among agents. Each arrow represents a flux of goods or services. For each of these fluxes there exist an opposite flux of money which is explicitly treated in the simulator.

4 Basic actions: sell-buy-produce

The simulation runs by steps. Each step includes the agent's basic action: sell, buy, and produce. Each of these steps is supposed to represent one year of the real life of the city.

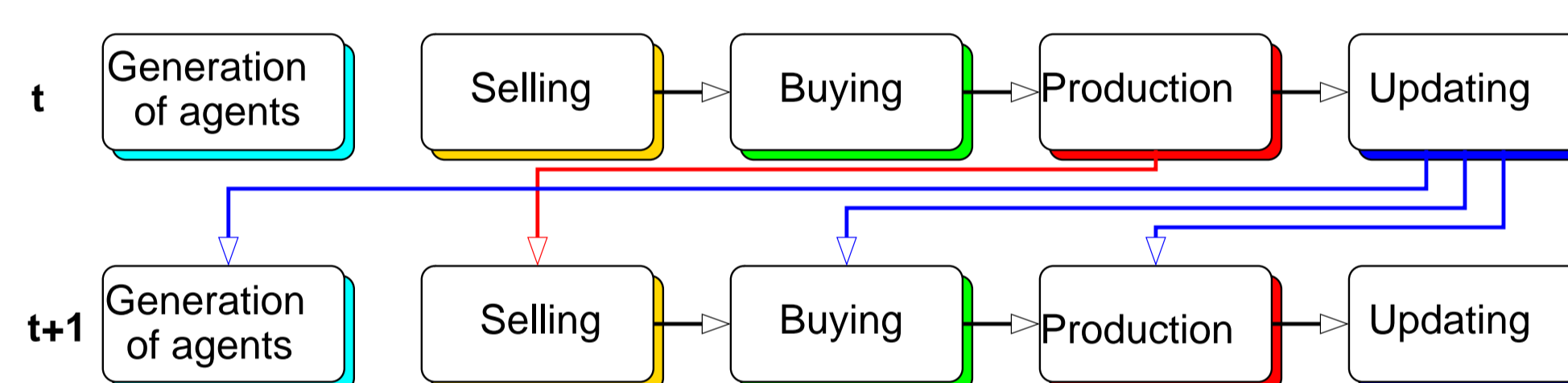


Figure 5: The time step dynamic of the model. During each step four main phases are performed: generation of agents, exchange in the markets (selling and buying), production, and finally updating

5 The simulation of Florence evolution

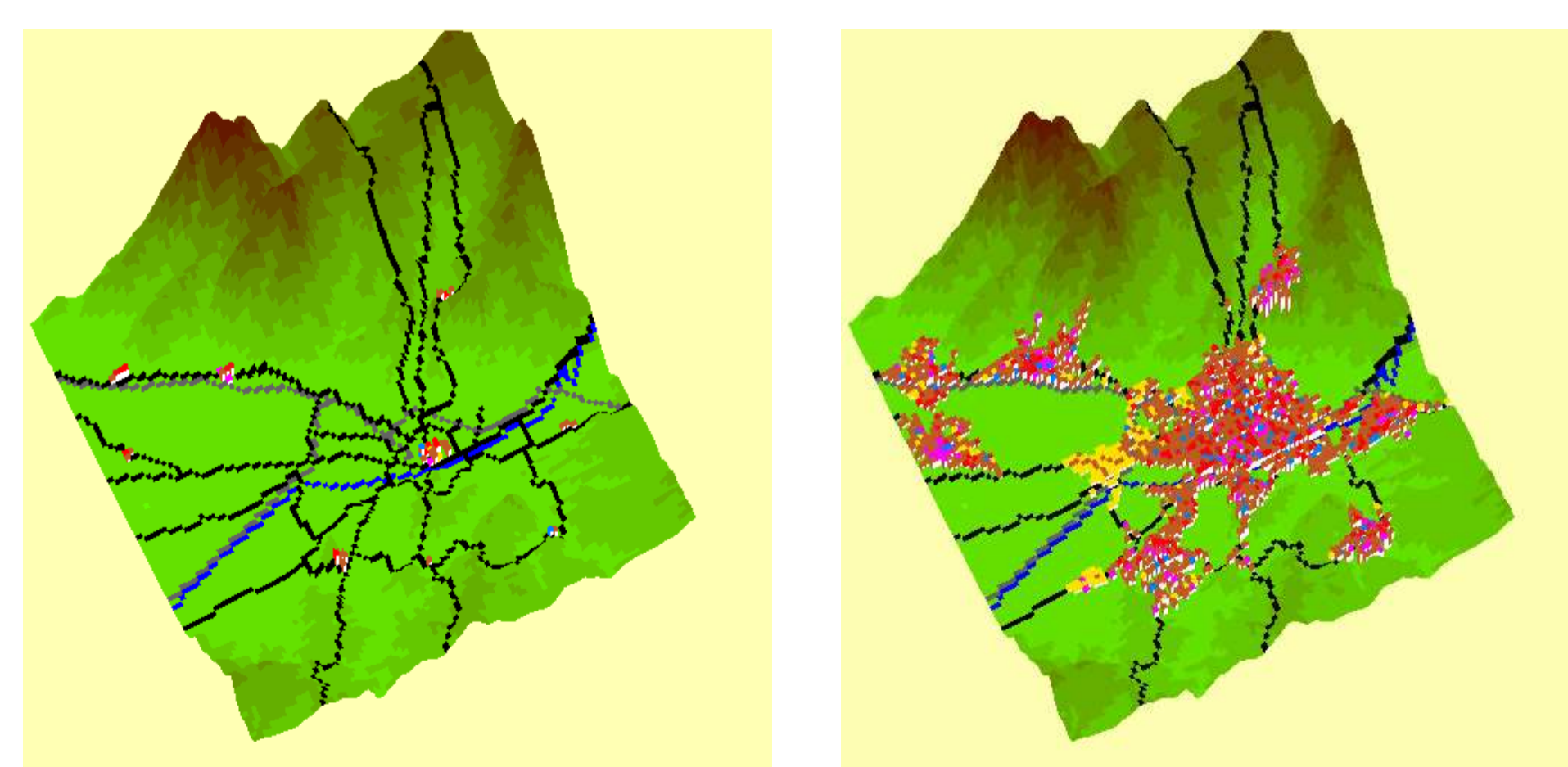


Figure 6: The evolution of Florence and its surrounding area. Left: step 10, right: step 300. Marron: Housing, red: commerce and offices, blue: Public services (schools, hospitals etc.), yellow: Industry

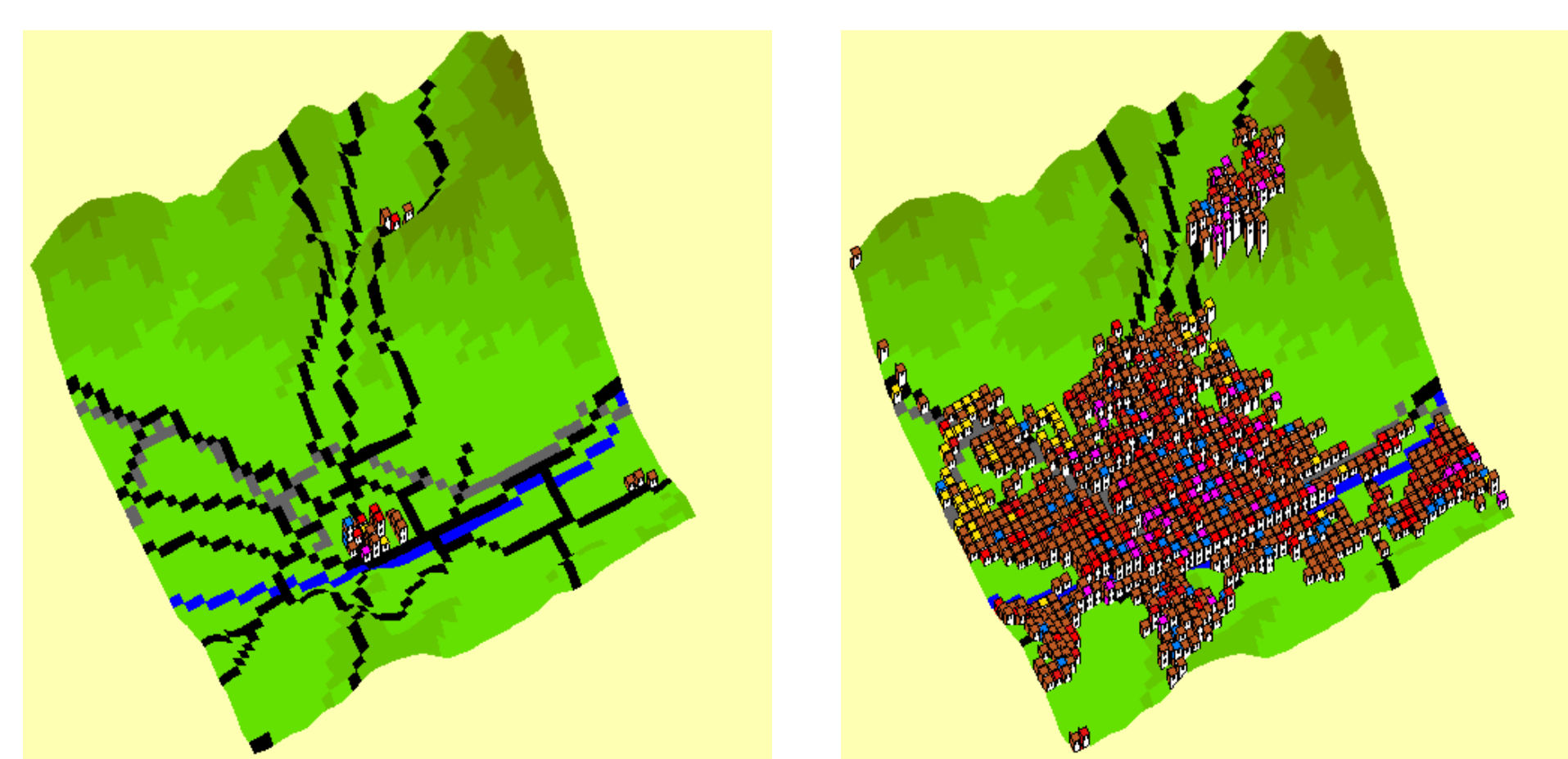


Figure 7: The evolution of Florence. Left: step 10, right: step 300.

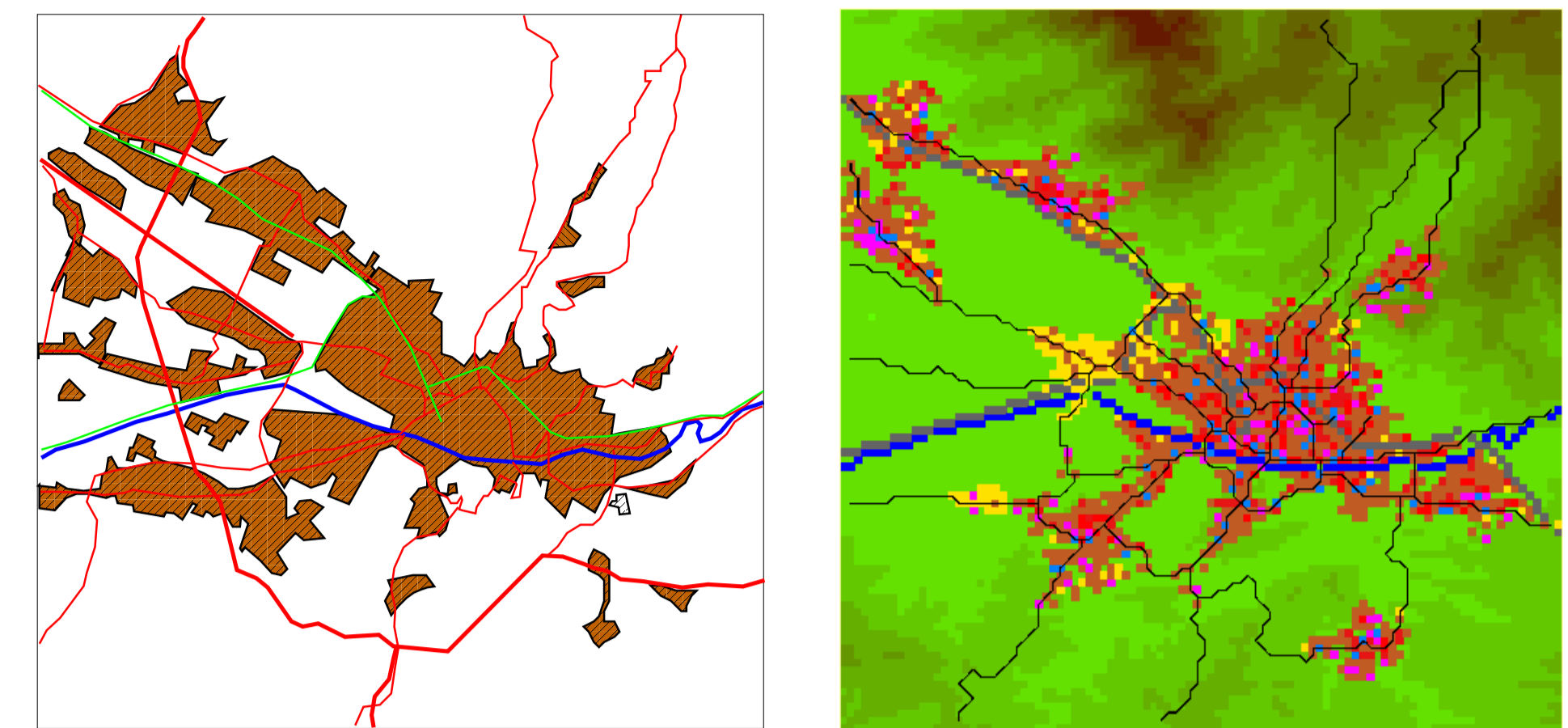


Figure 8: A comparison with the current urban pattern. Left: a sketch of the current urban pattern. Right: the simulation at step 300.

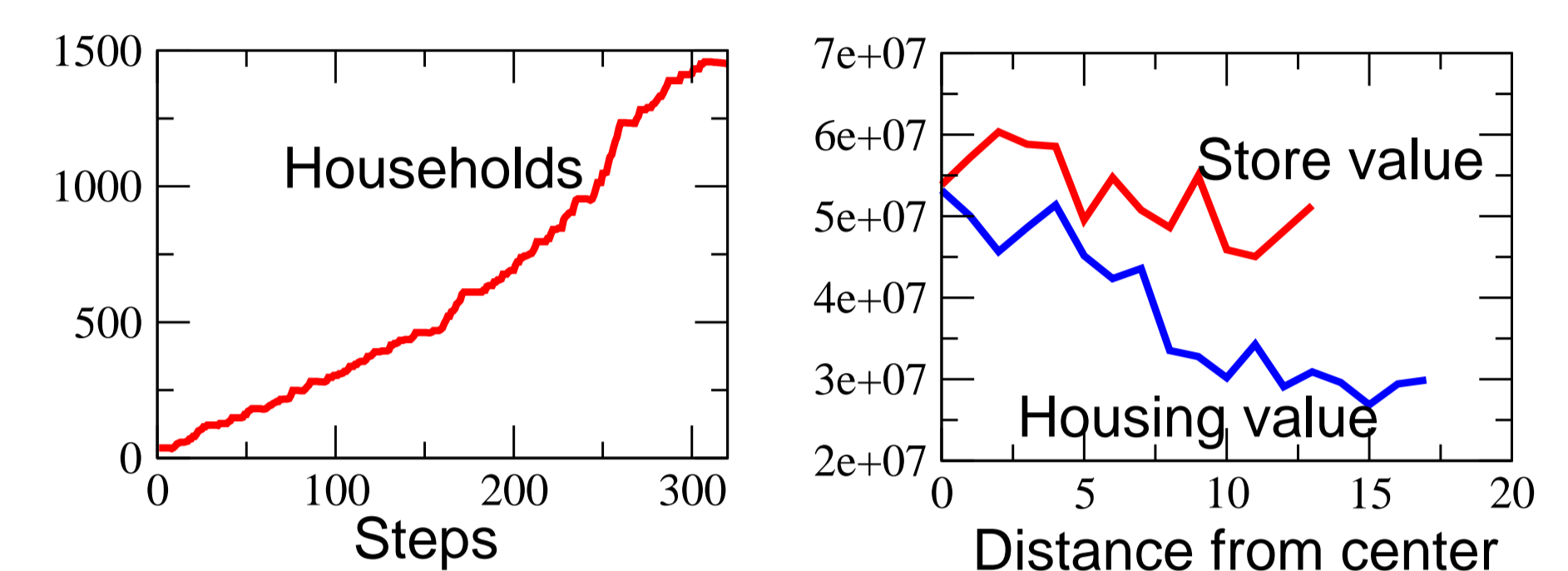


Figure 9: Left. The growth of the Households during the simulation. The steps 0 is supposed to correspond to 1700, step 300 to 2000. (For computational constraints, each Household represents 400 persons). Right: the decrease of store value (red) and of housing value (blue) with the increase of the distance from the city center.

6 The interaction with human users

Agent based simulation are well suited for generating scenarios in connection with the interaction with human user. A human user may manage one or more agents (developers for instance) in order to generate scenarios of the possible urban future patterns. This is a useful application of the complex system principles to the decision making. This interaction organized in a participatory simulation allows stakeholders to experiment their plan thus fostering a social learning process.

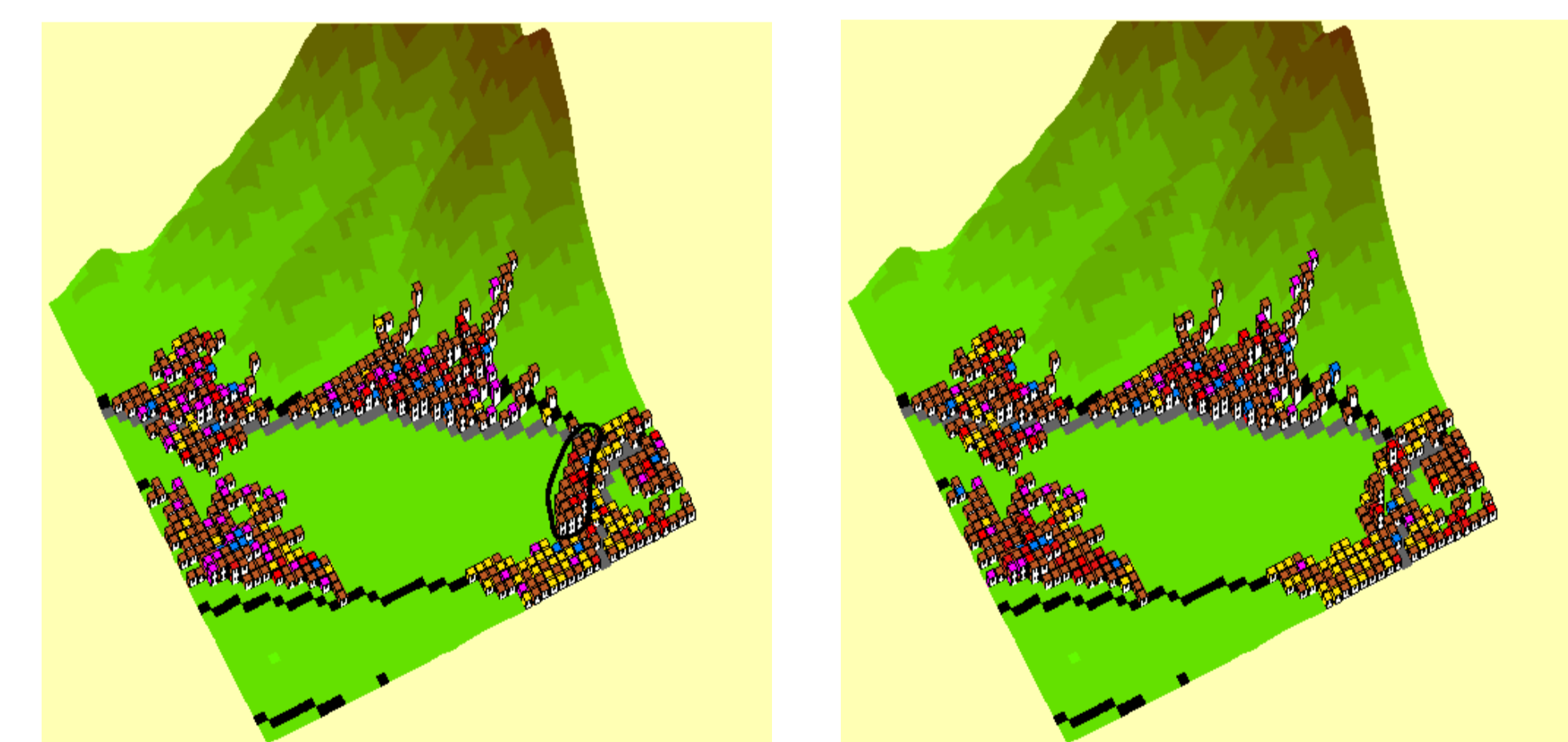


Figure 10: The urban pattern after 320 steps. Left: experiment with the area (north-east of Florence) developed by the developer managed by the human user (60 cells built); Right: spontaneous development (25 cells built).

7 Conclusions

Urban complexity is well simulated by the CityDev agent-based model which places in the center of the urban theory the human agent. In addition through the interaction with human users, this model emphasizes the role of agents in the conscious orientation of the urban system. This aspect corresponds to the new role of planning in the complex self-organized urban system.

8 Acknowledgments

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